Seeing Beyond Risk Canadian Institute of Actuaries Institut canadien des actuaires Voir au-delà du risque

Study

Canadian Individual Annuitant Mortality Experience – Policy Years 2002–2011

Annuitant Experience Subcommittee of the Research Committee

June 2014

Document 214067

Ce document est disponible en français

Seeing Beyond Risk Canadian Institute of Actuaries Institut canadien des actuaires Voir au-delà du risque

Memorandum

To: All Fellows, Affiliates, Associates and Correspondents of the Canadian Institute of Actuaries

From: Diana Pisanu, Chair
Annuitant Experience Subcommittee

Date: June 9, 2014

Subject: **Canadian Individual Annuitant Mortality Experience – Policy Years 2002–2011**

The attached document contains summary results for the Canadian Individual Annuitant Mortality Experience for Policy Years 2002–2011. There are a number of tables referenced in section 6 that will be available online at www.cia-ica.ca.

DP

360 Albert Street, Suite 1740, Ottawa ON K1R 7X7
613.236.8196 613.233.4552
head.office@cia-ica.ca / siege.social@cia-ica.ca
www.cia-ica.ca

Table of Contents

1. INTRODUCTION

This study updates the 2000–2009 study published in 2012, but the information presented here does not require knowledge of the prior study. Seven companies contributed to the 2010–2011 study. We acknowledge the assistance of these companies in compiling the data.

Joint policies were first included in the 1996–1997 study. They were excluded in prior years because of concerns about the reliability of the data. Our subcommittee remains concerned; however, adjusting for incurred but not reported (IBNR), which was added in the last report, should improve the accuracy of the tables with joint data. Because the IBNR factors are significantly larger for joint policies than for single policies, the data for single policies are considered more reliable. In the past, the mortality experience of joint life policies (both alive) was lower than single life policies. However, the differences between the two types of policies seem to decrease over time in recent years.

The mix of the business has changed slightly over the 10-year period. In general, the proportion of registered retirement savings plan (RRSP) business has decreased marginally, while the non-registered business has increased. The registered pension plan (RPP) business is small in proportion to the other two blocks. Please see section 3 Description of the Data for details.

Non-registered policies exhibit different characteristics from RRSP policies. Non-registered policies have higher income, lower mortality ratios, and higher mortality improvement when weighted by income, and exhibit more selection. You can find the details in the following pages.

Therefore, since sub-groups of the data exhibit different characteristics you should use the aggregate mortality ratios carefully. Mortality improvement in aggregate is suspect when sub-groups exhibit different mortality and mortality improvement.[1]

We have attempted to deduce the experience of back-to-back annuities. The data, although sparse, indicate there is much lower mortality for the block of business we isolated.

Similar to the study published in 2012, this study is conducted on the basis of "year of experience with IBNR", which we believe provides a better basis for analyzing year-by-year changes, such as rates of mortality improvement. This is described further in section 2 below.

2. DESCRIPTION OF THE STUDY

The study considers experience of Canadian individual annuities. Most of the policies studied are in payout status but in some cases experience is included during the deferred period, provided the policy has no cash value and the policy cannot be changed.

Policy Year/Calendar Year Basis

Some companies contribute data on a calendar year basis, but most contribute on a policy year basis (the study runs between successive policy anniversaries). The "year of experience", as the year under study is known, is referred to by the calendar year in which the study year ends.

The anniversary is based on the "determination date". This is the day on which the income was determined and may not be changed; there is a final disposition of funds on that date. Usually the determination date will be the same as the issue date. In the case of an accumulation-type annuity, the determination date would most likely be the date when the policy changes from accumulation status to payout status.

[1] See: Vaupel, James, and Anatoli Yashin. 'Heterogeneity's Ruses: Some Surprising Effects of Selection on Population Dynamics'. August 1985.

Reporting Method

Since 2010, the committee has used the year of experience with IBNR as the method of reporting. That is, the data reported for a year include the data originally reported for the year, all subsequent corrections submitted, and an estimate of IBNR. Each company submitting data is responsible for its own estimate of IBNR. The IBNR factors vary by sex, plan type (single, joint—both alive and survivor), and by the time elapsed since the year of experience. The factors are based primarily on the experience studies of the last several years of data in this study.

For most companies the IBNR factors start low and run off quickly for single life data. The factors generally are higher and persist longer for joint life (both alive and survivor) data.

The total IBNR for any year of experience is obtained by multiplying the deaths reported by the appropriate factor for sex, plan, and year. The exposure and expected are not adjusted. Because actual late reported deaths are unlikely to be the same as the IBNR estimate, the totals for a year of experience will not necessarily be the same in a subsequent report from the committee. We do not intend to draw the change to your attention unless it appears to be material.

All data shown in this document are on the basis of year of experience with IBNR to 2011.

Select Period

The study uses a 10-year select period. Since there is no published annuitant mortality table with the 10-year select period, the expected mortality for both the select and ultimate periods is calculated using an aggregate table: the 1983 IAM Basic Table, *Transactions* of the Society of Actuaries, Volume XXXIII.

Standard Deviation

This study includes standard deviations of the mortality ratios based on number of lives and income. ("Mortality ratio" means the ratio of the actual mortality to expected mortality). The standard deviation measures the degree of confidence that may be placed in the ratios observed. The formulae used to calculate the standard deviations are as follows:

$$\text{Standard Deviation by Number of Lives} = \frac{\left(\sum_t p_t \times q_t\right)^{0.5}}{\sum_t q_t}$$

$$\text{Standard Deviation by Income} = \frac{\left(\sum_t K_t^2 \times p_t \times q_t\right)^{0.5}}{\sum_t K_t \times q_t}$$

- Summation is over each individual;
- q's and p's are based on expected experience (1983 IAM Basic Table); and
- K represents the annualized income of the annuity.

For more information on the derivation of the standard deviation formulas, please refer to the appendix—Standard Deviation of A/E Ratios in Mortality Studies attached to this report.

Single and Joint Policies

Data are segregated by single life policies, joint policies in which both annuitants are alive at the beginning of the study year, and joint policies for which only one annuitant is still alive at the beginning of the year. We have concluded that there is a real and measurable difference in this mortality.

Data Breakdowns Studied

RRSP policies, RPP policies, and non-registered policies are studied separately.

Experience is also studied separately by refund and non-refund. A refund policy is one that provides for the possibility of some payment after the death of the annuitant. The most common refund provision is a continuation of payments for a minimum specified number of years.

A study of single life data by annualized income for males and females, RRSP and non-registered, is also done. There are four main income groups: up to $999; $1,000 up to $4,999; $5,000 up to $9,999, and $10,000 and over. We have also provided a further breakdown of the $10,000 and over category, although it should be used with caution.

Age-Nearest Birthday

All reports are done on the basis of age-nearest birthday. Most data are contributed on this basis. Any data submitted on an age-last birthday data are split, half to the age indicated and half to the next age. Because of the rounding needed by this split, the columns in the detailed reports often do not add exactly to the totals shown. However, the totals are all calculated before rounding and therefore are correct.

3. DESCRIPTION OF THE DATA

Unless indicated otherwise, this report uses single life data only.

Exposure by Sex

Males account for 44% of the exposure by number of policies, 47% of the exposure by income, and 49% of the number of deaths.

Exposure by Refund/Non-refund

There is less exposure for non-refund policies than refund policies. Refund business is 77%/75% of the exposure by policy for male/female single life policies from the 2002–2011 study years (70% and 69% respectively by income).

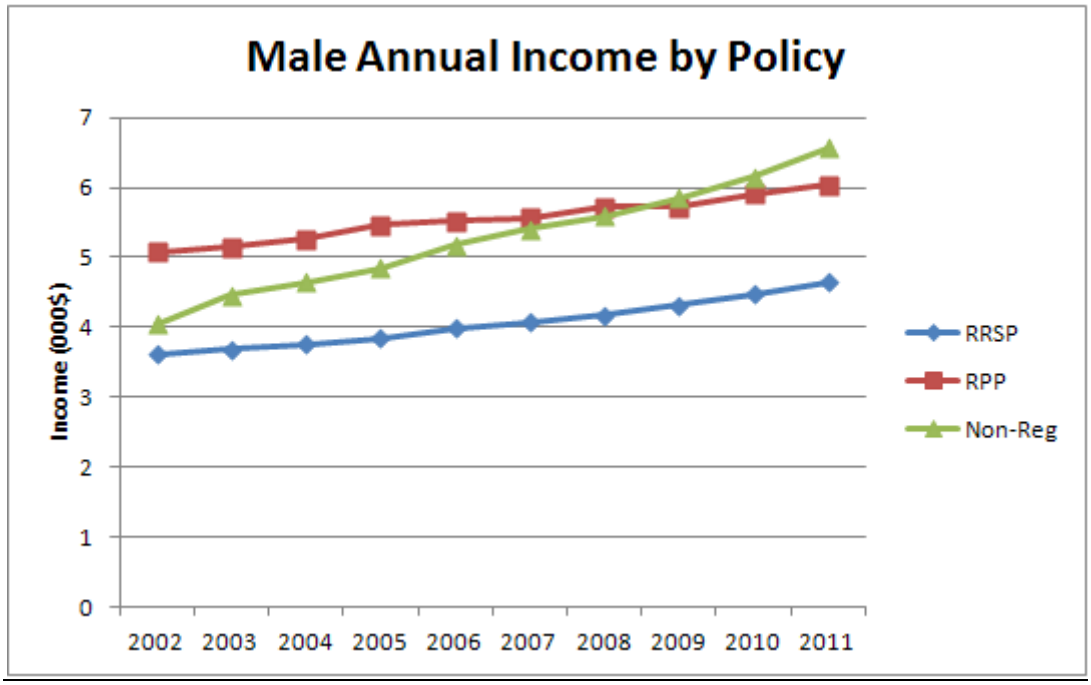
Changes in Average Annual Income by Tax Type and Sex

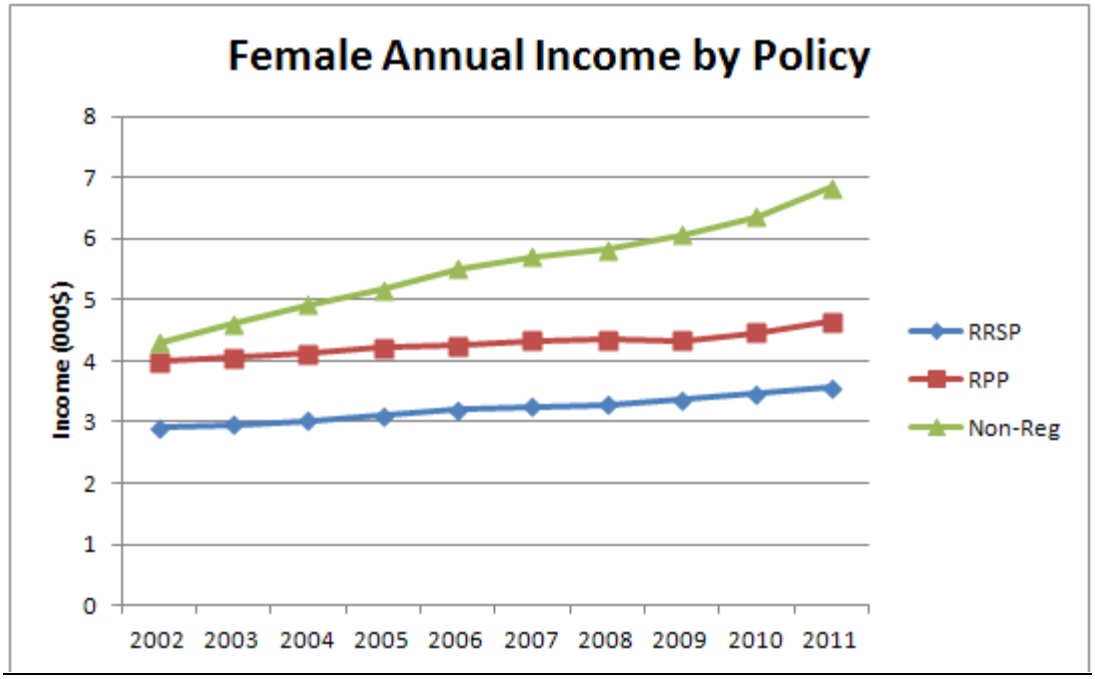
For males, the average annual income per policy for all tax types has been growing recently. Since 2009, the average income for non-registered policies is slightly higher than for RPP policies.

For females, the average annual income per policy for the non-registered tax type has continued to grow faster over the period of the study than the other tax types.

Note that for males, the average income for RPP policies is higher than for non-registered policies before 2009. We see the opposite for females. Further, for both males and females, the average income for non-registered policies is larger than for RRSP policies.

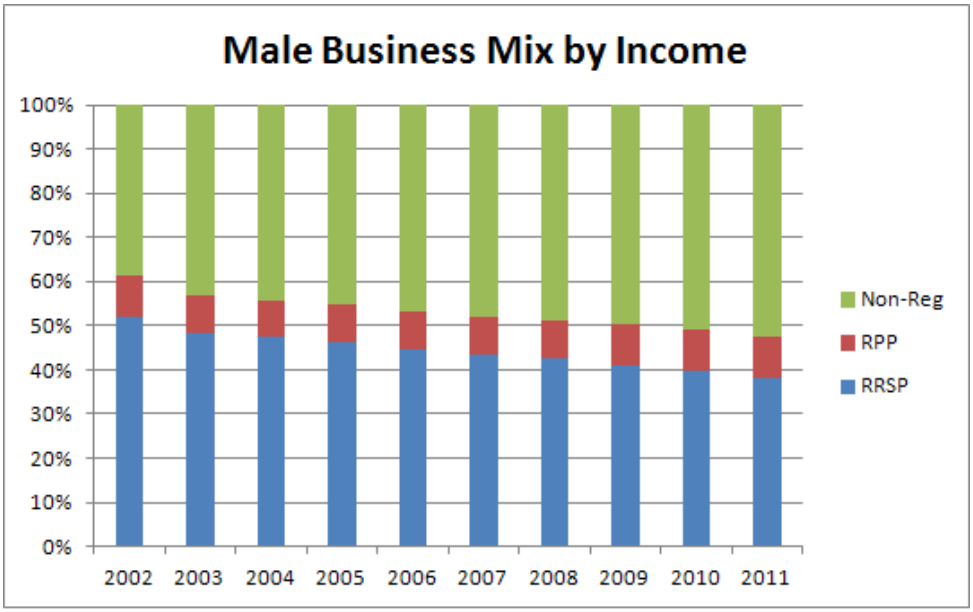
This is shown in the following charts.

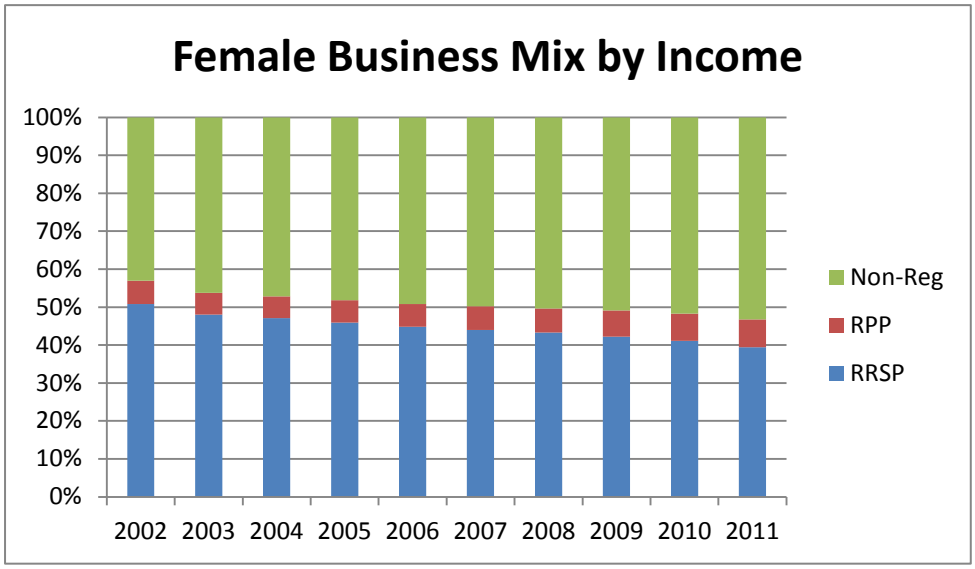




Change in Business Mix

Over time, the non-registered portion of the business has increased slightly, while the RRSP portion has decreased.





4. OBSERVATIONS

a) General Observations

The following tables give an overview of the data included in the study by years of experience.

The total of the Number Exposed for the individual study years represents the data included in this year's report. It will not be consistent with previous years' reports as some of the previous data will have been corrected.

During the study period, the A/E ratios by number of policies are greater than the A/E ratios by annualized income for single life data. For joint life data, the A/E ratios for joint survivors are greater than the A/E ratios for joint life (both annuitants alive) by number of policies and by annualized income.

Single Life Data

Study Year	Number Exposed	Number of Deaths	A/E by Policies	A/E by Income
2002	184,234	10,665	95.4%	88.0%
2003	192,191	11,821	96.7%	86.8%
2004	195,881	12,358	95.3%	83.4%
2005	187,887	12,374	95.4%	84.0%
2006	189,283	12,561	92.6%	84.3%
2007	179,433	12,230	91.3%	83.0%
2008	168,362	12,076	92.0%	81.0%
2009	161,752	11,989	92.1%	78.8%
2010	153,240	11,239	88.5%	77.4%
2011	145,788	10,790	87.2%	76.6%
Total	**1,758,052**	**118,104**	**92.6%**	**81.9%**

Joint Life Data (both annuitants alive at beginning of study year)

Study Year	Number Exposed	Number of Deaths	A/E by Policies	A/E by Income
2002	119,007	4,998	88.0%	85.0%
2003	117,256	5,025	84.8%	85.4%
2004	118,256	5,235	83.4%	81.2%
2005	114,124	5,161	82.3%	81.8%
2006	109,421	5,053	80.3%	77.6%
2007	101,780	4,995	82.3%	74.5%
2008	94,522	4,904	83.9%	79.5%
2009	90,252	4,804	83.9%	77.4%
2010	84,992	4,279	77.9%	72.4%
2011	80,726	4,012	75.5%	68.0%
Total	**1,030,336**	**48,467**	**82.3%**	**78.1%**

Joint Survivor Data (only one annuitant alive at beginning of study year)

Study Year	Number Exposed	Number of Deaths	A/E by Policies	A/E by Income
2002	38,694	2,241	95.6%	95.6%
2003	40,165	2,500	94.9%	93.4%
2004	43,053	3,012	100.0%	97.3%
2005	44,693	3,355	101.1%	97.7%
2006	46,539	3,407	92.8%	87.4%
2007	47,822	3,876	96.6%	95.3%
2008	49,099	4,303	99.3%	100.3%
2009	48,941	4,388	96.3%	96.0%
2010	48,598	4,568	96.4%	96.2%
2011	47,464	4,699	97.2%	93.6%
Total	**455,067**	**36,348**	**97.0%**	**95.4%**

b) Male/Female Observations

The following table summarizes aggregate male and female mortality ratios for single life data only.

The mortality ratios for males are greater than females by number of policies, but female A/E ratios are slightly higher by annualized income.

Aggregate Experience

Study Year	Number of Policies		Annualized Income	
	Male	**Female**	**Male**	**Female**
2002	95.0%	95.9%	87.1%	89.1%
2003	100.8%	92.5%	90.3%	82.6%
2004	96.4%	94.2%	84.3%	82.3%
2005	97.1%	93.8%	82.9%	85.3%
2006	93.3%	92.0%	81.4%	87.2%
2007	92.1%	90.5%	81.1%	84.9%
2008	93.2%	91.0%	78.1%	83.8%
2009	96.6%	88.3%	81.7%	75.8%
2010	91.7%	85.8%	75.2%	79.6%
2011	88.7%	86.0%	75.0%	78.0%
Total	**94.6%**	**90.8%**	**81.4%**	**82.4%**

As shown in the tables below, there is a distinct difference in mortality experience between RRSP and non-registered business for both males and females. Mortality ratios are much higher for RRSP than for non-registered and the mortality improvement is higher for non-registered business than for RRSP. However, the difference between RRSP and non-registered business is less significant with females than with males.

Male Experience

Study Year	Number of Policies		Annualized Income	
	RRSP	**Non-reg**	**RRSP**	**Non-reg**
2002	95.2%	94.0%	89.7%	80.8%
2003	101.1%	100.0%	94.0%	86.6%
2004	97.7%	93.5%	93.8%	73.4%
2005	102.3%	88.1%	97.2%	66.2%
2006	97.9%	85.2%	90.9%	66.8%
2007	94.4%	86.1%	89.3%	71.7%
2008	97.3%	87.0%	88.3%	64.8%
2009	100.6%	88.9%	89.4%	72.2%
2010	98.7%	80.8%	87.9%	59.1%
2011	95.0%	79.3%	93.4%	58.8%
Total	**98.1%**	**88.2%**	**91.4%**	**68.8%**

Female Experience

	Number of Policies		Annualized Income	
Study Year	**RRSP**	**Non-reg**	**RRSP**	**Non-reg**
2002	93.9%	98.6%	93.5%	83.9%
2003	93.1%	92.4%	90.5%	74.6%
2004	94.6%	92.2%	86.9%	77.2%
2005	93.9%	92.6%	93.9%	75.1%
2006	91.4%	94.1%	89.5%	85.3%
2007	91.5%	87.3%	85.2%	83.1%
2008	90.6%	90.5%	85.4%	82.3%
2009	89.7%	83.9%	87.0%	63.2%
2010	86.3%	84.4%	84.4%	75.4%
2011	88.8%	80.3%	87.3%	67.8%
Total	**91.3%**	**89.3%**	**88.0%**	**76.3%**

The following charts show the trend in mortality ratios measured by income. The dots in the charts represent the ratios of actual to expected deaths. The dashes represent plus and minus one standard deviation. The trend line shown is an exponential regression line of the ratios of actual to expected deaths.

An exponential trend line is more appropriate than a linear regression line tool for determining the rate of improvement implied by the data. When the mortality ratios are close to 100%, there is little difference between the two methods. As the mortality ratio moves away from 100%, the exponential improvement rate becomes higher than the linear improvement rate.

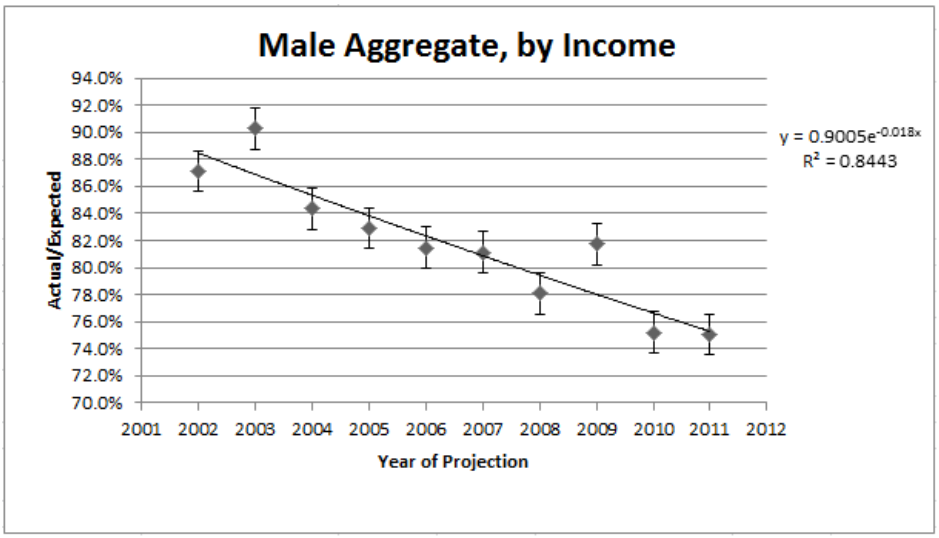
The exponential trend line is represented by the following formula, where *"a"* indicates the rate of improvement:

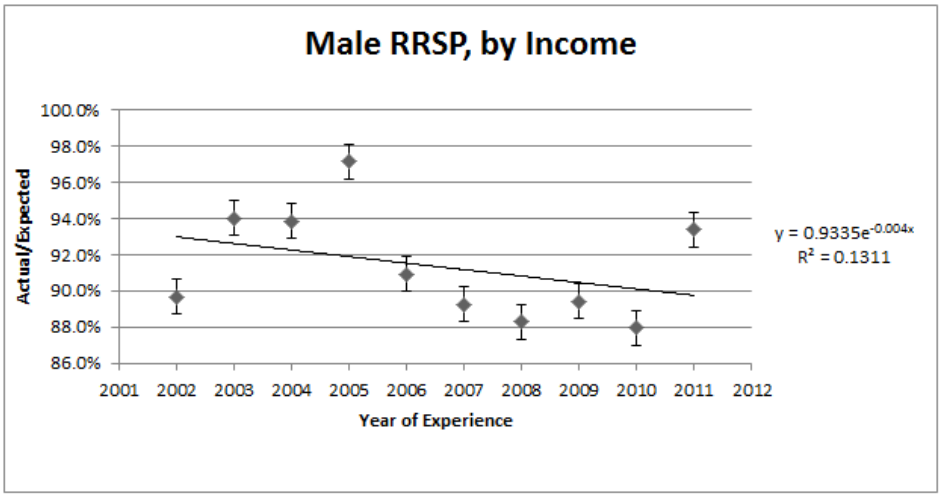
$$Y = b \times e^{ax}$$

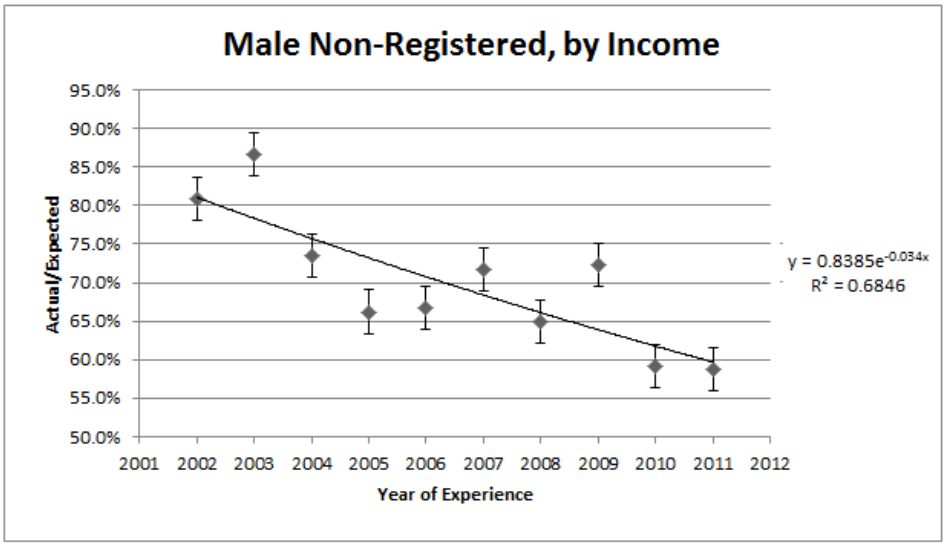
The charts include the equation for the trend line indicating the rate of improvement and the R^2 statistic determined from the regression analysis. R^2 is the proportion of the total variation in the Y variable explained by the regression of Y on X and ranges from 0 to 1. An R^2 of 0 occurs when the regression model does nothing to help explain the variation in Y, whereas, an R^2 of 1 indicates that the linear regression model completely explains the variation in Y.

The first three charts show male mortality ratios by income. The first chart is for all-male data. The second and third charts are for RRSP only and non-registered-only business.

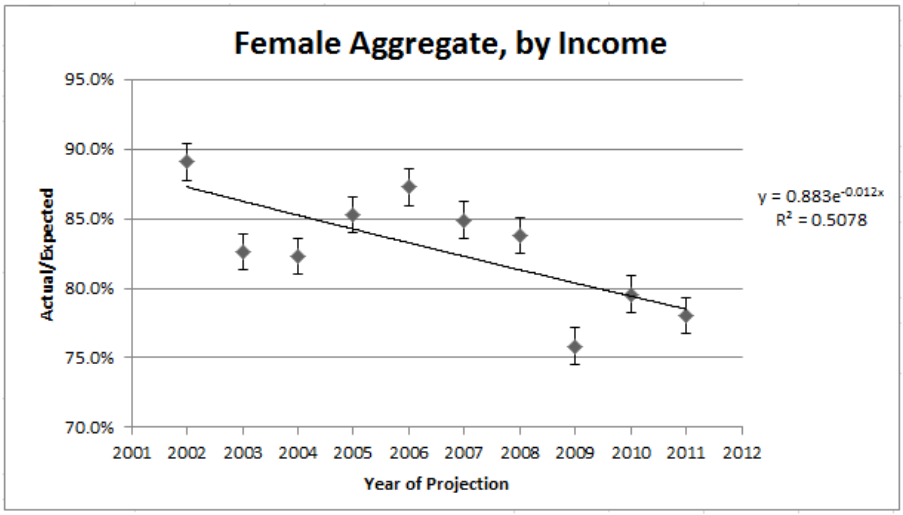
The *"a"* factor is negative, indicating improvement in mortality. The *"a"* factor for the RRSP business indicates a weaker improvement in mortality while the improvement rate for non-registered business is greater. The R^2 value in the Male Aggregate and Male Non-reg cases would indicate that the trend line is more than just a random phenomenon and that there is an indication that mortality improvement is occurring, though at different rates. The considerably smaller value of R^2 for RRSP compared to last year's study is due to more volatile experience during the 10-year study period.

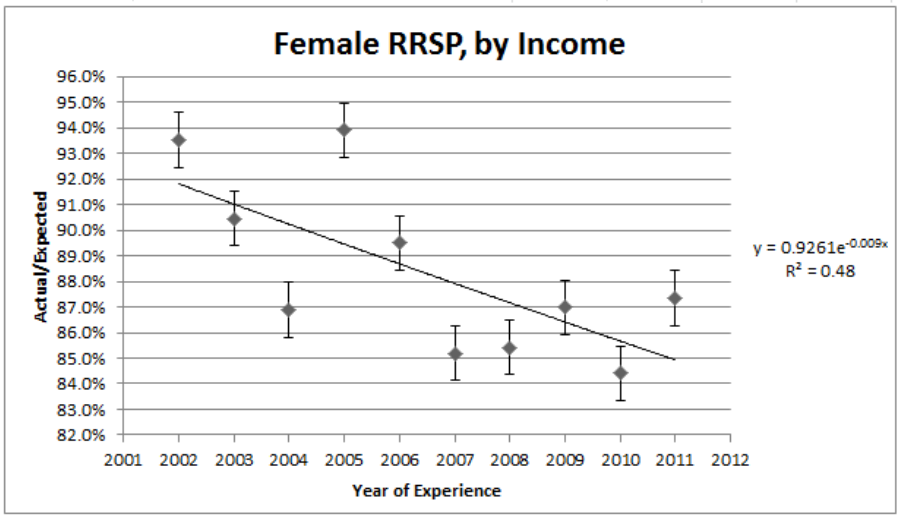

Male Aggregate, by Income
Actual/Expected
94.0%
92.0%
90.0%
88.0%
86.0%
84.0%
82.0%
80.0%
78.0%
76.0%
74.0%
72.0%
70.0%
2001 2002 2003 2004 2005 2006 2007 2008 2009 2010 2011 2012
Year of Projection
y = 0.9005e-0.018x
R² = 0.8443

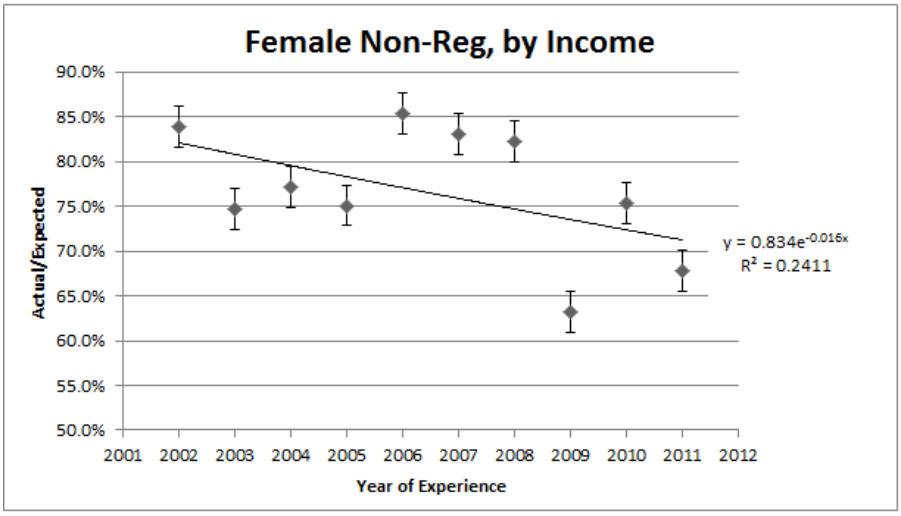

Male RRSP, by Income
Actual/Expected
100.0%
98.0%
96.0%
94.0%
92.0%
90.0%
88.0%
86.0%
2001 2002 2003 2004 2005 2006 2007 2008 2009 2010 2011 2012
Year of Experience
y = 0.9335e-0.004x
R² = 0.1311


Male Non-Registered, by Income
Actual/Expected
95.0%
90.0%
85.0%
80.0%
75.0%
70.0%
65.0%
60.0%
55.0%
50.0%
2001 2002 2003 2004 2005 2006 2007 2008 2009 2010 2011 2012
Year of Experience
y = 0.8385e-0.034x
R² = 0.6846

The next three charts are similar to the first three but for female single life policies. Again, the *"a"* factor is negative, indicating improvement in mortality in all three cases. The *"a"* factor for RRSP seems to indicate a weaker improvement in mortality. The R^2 values are relatively small for all three cases. Therefore, it is difficult to determine whether or not the trend line is more than just a random phenomenon.







c) Income Study Observations (Single Life Data Only)

As in previous studies, we observe lower Actual/Expected ratios for high income bands. This relationship is seen in the gender-specific results. This supports the notion that individuals with higher income exhibit lower mortality.

The pattern of decrease in mortality ratio with policy size is observed in all categories. By splitting Male/Female overall $10,000+ band into sub-bands, we observe that decreasing trend is still present (shown below). The decreasing pattern is also observed in the RRSP-only and Non-registered-only results.

The following tables provide an overview of the data included in the policy year 2002–2011 income study.

Overall

	Exposed		Deaths		Actual/Expected		Standard Deviation	
Income Band	**Policies**	**Income**	**Policies**	**Income**	**Policies**	**Income**	**Policies**	**Income**
0–1,000	426,204	252,956	33,423	19,159	97.5%	96.4%	0.5%	0.6%
1,000–5,000	920,701	2,180,496	62,567	144,631	93.3%	92.9%	0.4%	0.4%
5,000–10,000	255,002	1,763,038	14,575	100,178	88.0%	87.8%	0.7%	0.8%
10,000+	156,145	3,420,447	7,539	144,612	78.2%	69.1%	1.0%	1.8%
Total	1,758,052	7,616,937	118,104	408,580	92.6%	81.9%	0.3%	0.8%

Overall by Male/Female Split

	Male				Female			
	Actual/Expected		Standard Deviation		Actual/Expected		Standard Deviation	
Income Band	**Policies**	**Income**	**Policies**	**Income**	**Policies**	**Income**	**Policies**	**Income**
0–1,000	99.3%	98.5%	0.7%	0.8%	95.8%	94.5%	0.7%	0.8%
1,000–5,000	96.0%	95.4%	0.5%	0.6%	91.0%	90.7%	0.5%	0.6%
5,000–10,000	89.9%	89.6%	1.1%	1.1%	86.3%	86.2%	1.0%	1.0%
10,000+	78.5%	67.4%	1.3%	2.6%	77.9%	71.3%	1.4%	2.5%
Total	94.6%	81.4%	0.4%	1.2%	90.8%	82.4%	0.4%	1.0%

Income Band $10,000+ Further Broken Down by Sub-bands

	Male				Female			
	Actual/Expected		Standard Deviation		Actual/Expected		Standard Deviation	
Income Band	**Policies**	**Income**	**Policies**	**Income**	**Policies**	**Income**	**Policies**	**Income**
10,000–20,000	84.0%	83.6%	1.6%	1.6%	80.0%	79.8%	1.7%	1.7%
20,000–50,000	68.9%	67.5%	2.6%	2.6%	72.9%	71.9%	3.0%	3.1%
50,000+	54.5%	41.1%	5.8%	9.2%	66.9%	52.7%	7.0%	9.7%

RRSP Only

	Male				Female			
	Actual/Expected		Standard Deviation		Actual/Expected		Standard Deviation	
Income Band	**Policies**	**Income**	**Policies**	**Income**	**Policies**	**Income**	**Policies**	**Income**
0–1,000	103.8%	103.3%	1.0%	1.1%	95.7%	94.1%	0.9%	1.0%
1,000–5,000	98.5%	97.7%	0.7%	0.7%	91.0%	90.9%	0.6%	0.7%
5,000–10,000	93.0%	92.6%	1.4%	1.4%	86.0%	86.0%	1.4%	1.4%
10,000+	84.9%	82.1%	1.9%	2.4%	80.8%	82.8%	2.4%	2.7%
Total	98.1%	91.4%	0.5%	0.9%	91.3%	88.0%	0.5%	0.8%

Non-registered Only

	Male				Female			
Income Band	**Actual/Expected**		**Standard Deviation**		**Actual/Expected**		**Standard Deviation**	
0–1,000	93.3%	91.9%	1.1%	1.2%	96.2%	94.7%	1.2%	1.3%
1,000–5,000	89.6%	88.9%	1.0%	1.1%	90.2%	89.6%	0.9%	1.0%
5,000–10,000	83.8%	83.8%	1.8%	1.9%	85.2%	85.1%	1.6%	1.6%
10,000+	71.0%	56.3%	1.9%	4.3%	75.7%	66.3%	1.8%	3.4%
Total	88.2%	68.8%	0.6%	2.6%	89.3%	76.3%	0.6%	1.9%

d) Tax Observations

Since the study is on individual business rather than group, there is a relatively small amount of RPP business compared to RRSP and non-registered. One would expect the A/E ratio to be the highest for RPP and the lowest for non-registered (as in the RPP category the annuitant must annuitize as opposed to choosing to). The table below shows a summary of the single life data by tax type. Although the A/E relationship is as expected by number of policies, the A/E ratios by income are slightly higher for RRSP than RPP.

	Exposed		Deaths		Actual/Expected		Standard Deviation	
Tax	**Policies**	**Income**	**Policies**	**Income**	**Policies**	**Income**	**Policies**	**Income**
RRSP	959,703	3,384,359	71,368	218,229	94.4%	89.8%	0.3%	0.6%
RPP	117,137	573,257	6,061	23,817	98.9%	89.0%	1.2%	2.4%
Non-reg	681,213	3,659,321	40,676	166,534	88.8%	72.7%	0.4%	1.6%
Total	1,758,052	7,616,937	118,104	408,580	92.6%	81.9%	0.3%	0.8%

It is possible that what we are seeing is a phantom of heterogeneity in the data. Notice that the average annual income for RRSP is $3,500, for RPP is $4,900, and for non-registered is $5,400. Since experience improves with increasing size, it is possible that the difference due to tax type is really less than the table indicates.

To see if the income size explains the anomaly, some modification was made to the data. The modification is analogous to age-adjusting, but a little more complex. The modification was applied to exposure by income band, age, and duration, keeping the totals and exposure by sex, plan, and tax to be unchanged. The actual mortality rate in each cell is applied to the revised distribution of exposure. The revised A/E ratio is valid and the standard deviation is approximately correct. Due to data limitation in the younger ages, the modification can only be made to age range 50 to 99. The age range accounts for more than 96% of the data (in terms of exposure and death) so the analysis should still be valid.

The following table shows the A/E ratio and standard deviation for the original and the modified data. It shows that the A/E ratios are as expected.

Tax	Original Data				Modified Data			
	Actual/Expected		Standard Deviation		Actual/Expected		Standard Deviation	
	Policies	Income	Policies	Income	Policies	Income	Policies	Income
RRSP	94.4%	89.8%	0.3%	0.6%	93.8%	86.6%	0.5%	1.7%
RPP	98.9%	89.0%	1.2%	2.4%	100.7%	92.6%	1.5%	2.7%
Non-reg	88.8%	72.7%	0.4%	1.6%	91.7%	80.1%	0.5%	1.0%
Total	92.6%	81.9%	0.3%	0.8%	93.5%	84.0%	0.3%	0.9%

Similar adjustment was completed for males and females separately to determine if the same pattern occurs for each sex. The following table shows that it does. For female, the A/E ratios by policy for RRSP and non-registered are essentially the same. Given the size of the standard deviation, we cannot state whether this is merely a statistical fluctuation.

Tax	Male				Female			
	Actual/Expected		Standard Deviation		Actual/Expected		Standard Deviation	
	Policies	Income	Policies	Income	Policies	Income	Policies	Income
RRSP	97.3%	88.7%	0.7%	2.8%	90.6%	84.2%	0.6%	1.5%
RPP	103.5%	94.1%	1.9%	3.1%	97.1%	89.9%	2.3%	4.7%
Non-reg	92.5%	79.0%	0.7%	1.6%	90.8%	81.2%	0.7%	1.3%
Total	95.8%	84.7%	0.5%	1.5%	91.0%	83.1%	0.4%	1.0%

e) Select/Ultimate Observations

The following tables give an overview of the select and ultimate single life mortality ratios in the 2002–2011 policy-year study. When we look at the overall study results, we can make the following assertions:

- There is self-selection;
- The self-selection is mainly present during a select period of approximately 10 years (after 10 years the impact of self-selection decreases rapidly); and
- Self-selection is greater during the first six years following the policy issuance.

Overall Select-Ultimate Mortality Experience (10-year Select Period)

	A/E Ratio		SD		Ultimate less Select A/E ratio		SD	
Policy Year	**Policies**	**Income**	**Policies**	**Income**	**Policies**	**Income**	**Policies**	**Income**
1	49.1%	33.4%	3.4%	10.3%	45.3%	55.5%	3.4%	10.3%
2	60.9%	44.4%	3.3%	8.4%	33.5%	44.5%	3.3%	8.5%
3	68.2%	53.6%	3.2%	9.2%	26.2%	35.3%	3.2%	9.2%
4	72.5%	51.8%	3.1%	9.3%	21.9%	37.1%	3.1%	9.3%
5	76.2%	62.8%	2.9%	9.2%	18.2%	26.0%	2.9%	9.2%
6	74.4%	62.6%	2.8%	9.0%	20.0%	26.3%	2.8%	9.0%
7	83.5%	56.0%	2.6%	8.8%	10.9%	32.9%	2.6%	8.8%
8	80.8%	64.3%	2.5%	8.7%	13.6%	24.6%	2.5%	8.7%
9	81.6%	64.5%	2.4%	8.4%	12.8%	24.4%	2.4%	8.4%
10	85.4%	74.5%	2.2%	7.5%	9.0%	14.4%	2.2%	7.5%
Ultimate	94.4%	88.9%	0.3%	0.6%				
Total	**92.6%**	**81.9%**	**0.3%**	**0.8%**				

Overall Select-Ultimate Mortality Experience (25-year Select Period)

	A/E Ratio		SD		Ultimate less Select A/E		SD	
Policy Year	**Policies**	**Income**	**Policies**	**Income**	**Policies**	**Income**	**Policies**	**Income**
0–5	66.4%	49.5%	1.4%	4.2%	32.9%	43.3%	1.5%	4.3%
5–10	81.6%	64.5%	1.1%	3.8%	17.7%	28.3%	1.2%	4.0%
10–15	88.8%	83.3%	0.8%	2.1%	10.5%	9.5%	0.9%	2.4%
15–20	90.9%	87.3%	0.6%	1.1%	8.4%	5.5%	0.7%	1.5%
20–25	95.0%	91.4%	0.5%	0.9%	4.3%	1.4%	0.7%	1.4%
Ultimate	99.3%	92.8%	0.5%	1.1%				
Total	**92.6%**	**81.9%**	**0.3%**	**0.8%**				

Income Band Analysis

Further splitting the data by income band, we see a clear relationship between self-selection and income band. This supports the notion that individuals investing a larger amount of money in annuity products are well informed of their health, thus increasing the impact of self-selection.

Select-Ultimate Mortality Experience by Income Band[2] (10-Year Select Period)

	Ultimate less Select A/E ratio		Standard Deviation	
Income Band	**Policies**	**Income**	**Policies**	**Income**
0–999	11.7%	11.8%	2.5%	2.6%
1,000–4,999	14.1%	14.4%	1.4%	1.5%
5,000–9,999	17.7%	17.6%	2.1%	2.1%
10,000+	21.4%	31.8%	2.2%	4.3%
Total	**18.6%**	**31.6%**	**0.9%**	**2.9%**

Tax Type Analysis

To see if the income size explains the self-selection for non-registered contracts, some modification was made to the data. The modification is analogous to income band and age-adjusting, but a little more complex. The modification was applied to exposure by income band and age, keeping the totals and exposure by sex, plan, and tax to be unchanged. The actual mortality rate in each cell is applied to the revised distribution of exposure. Due to data limitation in the younger ages, the modification can only be made to age range 50 to 99. The age range accounts for more than 96% of the data (in terms of exposure and death) so the analysis should still be valid.

The following table shows the ultimate less select A/E ratio for the original and the modified data. After the exposure was modified by income band and age, we do not observe a clear self-selection pattern by tax type. As a result, we conclude that the main reason behind the greater self-selection on non-registered contract is the greater proportion of higher-income annuitants in this type of contract.

Select-Ultimate Mortality Experience by Tax Type[2] (10-Year Select Period)

	Original Data		Modified Data	
	Ultimate less Select A/E Ratio		Ultimate less Select A/E Ratio	
	Policies	**Income**	**Policies**	**Income**
Non-reg	18.9%	32.9%	21.9%	28.9%
RRSP	18.2%	21.2%	21.2%	26.4%
RPP	9.1%	7.8%	22.3%	25.9%
Total	**18.8%**	**32.0%**	**21.8%**	**28.3%**

Sex and Issue Year Analysis

There is no clear conclusion about self-selection depending on annuitant sex or issue year.

f) Non-refund/Refund Observations

There are a number of difficulties with comparing refund and non-refund business:

- There is much less non-refund business than refund, although the percentage of non-refund business has been increasing in the last few study years;

[2] A select period of 10 years has been used. The difference between the actual/expected ratio during the select and the ultimate period has been used as a measurement of self-selection.

- Refund business is far from homogeneous: both life five-year certain and life certain to age 90 qualify as refund; and
- Some companies have difficulties in classifying refund business correctly after the certain period has expired.

In spite of these concerns, there are some interesting observations to be made. For single life policies, the non-refund mortality ratio is lower than the refund mortality when measured by annualized income for both male and female annuitants (little differences when measured by number of policies).

The mortality ratios are also clearly lower for non-refund under non-registered policies (partly due to greater proportion of higher income annuitants), at higher bands and also in the first 10 study years. These experiences certainly warrant caution in pricing non-refund annuities.

One possible explanation for the difference observed based on refund status is that the annuitants may have additional information on their health status, such as under back-to-back policies, and they will choose the appropriate type of annuity. Thus one could expect that annuitants who choose non-refund policies believe that they have a good health status and they are willing to receive a higher annuity income at the risk of getting nothing at time of death.

The following table shows both mortality ratios and standard deviations for single life policies. As can be seen by the standard deviations for the non-refund ratios, there is a greater degree of uncertainty with these results.

		Exposure		Deaths		Actual/Expected		Standard Deviation	
	Refund	**Policies**	**Income**	**Policies**	**Income**	**Policies**	**Income**	**Policies**	**Income**
Total	No	428,876	2,354,983	34,485	132,217	92.6%	73.6%	0.5%	1.8%
Total	Yes	1,329,176	5,261,954	83,618	276,364	92.6%	86.6%	0.3%	0.7%
Total	All	1,758,052	7,616,937	118,104	408,580	92.6%	81.9%	0.3%	0.8%
Male	No	180,295	1,088,954	15,400	63,422	93.1%	71.5%	0.7%	2.9%
Male	Yes	592,644	2,484,655	42,198	143,280	95.2%	86.7%	0.4%	1.0%
Female	No	248,582	1,266,028	19,086	68,794	92.3%	75.7%	0.7%	2.0%
Female	Yes	736,532	2,777,299	41,421	133,084	90.1%	86.4%	0.4%	1.0%
Male	All	772,939	3,573,610	57,597	206,702	94.6%	81.4%	0.4%	1.2%
Female	All	985,114	4,043,327	60,507	201,878	90.8%	82.4%	0.4%	1.0%
Non-registered	No	185,672	1,434,832	12,737	64,063	87.2%	61.6%	0.8%	2.9%
Non-registered	Yes	495,541	2,224,489	27,939	102,471	89.5%	82.0%	0.5%	1.5%
RRSP	No	214,265	772,491	19,778	60,065	95.8%	90.1%	0.6%	1.2%
RRSP	Yes	745,438	2,611,868	51,590	158,164	93.9%	89.7%	0.4%	0.7%
Band 0–999	No	106,475	59,892	10,565	5,691	100.4%	99.1%	0.9%	1.0%
Band 1,000–4,999	No	208,635	501,143	16,994	39,506	94.4%	93.0%	0.7%	0.8%
Band 5,000–9999	No	62,646	432,709	4,256	29,397	86.4%	86.6%	1.3%	1.4%
Band 10,000–19,999	No	32,258	437,792	1,858	25,299	76.1%	75.9%	1.9%	1.9%
Band 20,000–49,999	No	14,809	423,040	662	18,442	61.9%	59.9%	2.9%	3.0%
Band 50,000+	No	4,055	500,406	151	13,881	55.6%	41.7%	5.7%	8.8%
Band 0-999	Yes	319,730	193,065	22,857	13,468	96.2%	95.3%	0.6%	0.7%
Band 1,000–4,999	Yes	712,065	1,679,352	45,574	105,125	92.9%	92.8%	0.4%	0.5%
Band 5,000–9999	Yes	192,357	1,330,328	10,319	70,781	88.7%	88.4%	0.9%	0.9%
Band 10,000–19,999	Yes	77,346	1,033,003	3,735	49,594	85.4%	85.1%	1.4%	1.5%
Band 20,000–49,999	Yes	24,035	666,433	1,014	28,190	77.7%	77.3%	2.6%	2.7%
Band 50,000+	Yes	3,644	359,774	119	9,206	65.5%	54.0%	7.1%	9.9%
Dur 1–10	No	62,882	884,450	1,705	18,649	61.8%	39.2%	1.8%	5.4%
Dur 1–10	Yes	294,511	1,663,075	7,621	44,433	79.8%	71.0%	1.0%	2.7%
Ultimate	No	365,995	1,470,532	32,781	113,567	95.1%	86.0%	0.5%	1.4%
Ultimate	Yes	1,034,665	3,598,879	75,997	231,930	94.1%	90.4%	0.3%	0.6%

Income Band Analysis

Analyzing the data further by income band and comparing non-registered and RRSP policies, we can see very little difference between non-refund and refund RRSP polices at each band. However, non-registered polices show significant differences at the higher bands.

	RRSP					
	Non-refund		Refund		Non-refund - Refund	
	Policies	Income	Policies	Income	Policies	Income
Band 0–999	101.7%	99.9%	98.2%	97.3%	3.6%	2.6%
Band 1,000–4,999	95.4%	94.1%	94.0%	94.1%	1.4%	0.0%
Band 5,000–9999	90.7%	91.2%	89.2%	88.7%	1.5%	2.5%
Band 10,000+	81.1%	82.0%	84.1%	82.5%	-2.9%	-0.4%
Total	95.8%	90.1%	93.9%	89.7%	1.9%	0.5%
	Non-registered					
	Non-refund		Refund		Non-refund - Refund	
	Policies	Income	Policies	Income	Policies	Income
Band 0–999	97.9%	96.9%	93.0%	91.6%	4.9%	5.3%
Band 1,000-4,999	91.7%	90.3%	89.3%	88.9%	2.3%	1.4%
Band 5,000–9999	80.1%	80.1%	87.0%	87.0%	-6.9%	-6.9%
Band 10,000+	64.3%	51.4%	82.3%	74.2%	-18.0%	-22.8%
Total	87.2%	61.6%	89.5%	82.0%	-2.3%	-20.4%

g) Back-to-Back Policy Observations

The subcommittee attempted to isolate the experience of back-to-back annuities. In this study, we presume that the non-refund and non-registered policies with higher income bands are back-to-back annuities. The following table compared the non-refund and non-registered policies by income bands for single life policies.

Although the data for non-refund and non-registered policies are sparse, they indicate that single life policies with income higher than $20,000 have significantly lower mortality ratios.

By splitting the isolated business by male and female, we observe that the mortality ratios are lower for the isolated block of business with income higher than $20,000 as well.

Single, Non-refund, and Non-registered Experience Only

	Exposure		Deaths		Actual/Expected		Standard Deviation	
	Policies	Income	Policies	Income	Policies	Income	Policies	Income
Band 0–999	49,172	26,238	4,266	2,138	97.9%	96.9%	1.4%	1.6%
Band 1,000–4,999	74,795	180,689	5,154	12,069	91.7%	90.3%	1.3%	1.4%
Band 5,000–9999	28,729	200,569	1,735	12,155	80.1%	80.1%	2.0%	2.1%
Band 10,000–19,999	18,742	257,812	1,041	14,527	72.4%	72.6%	2.5%	2.5%
Band 20,000–49,999	10,624	305,004	419	11,589	53.5%	51.2%	3.4%	3.5%
Band 50,000+	3,611	464,519	122	11,585	51.0%	37.8%	6.1%	9.4%
Total	185,672	1,434,832	12,737	64,063	87.2%	61.6%	0.8%	2.9%

Single, Male, Non-refund, and Non-registered Experience Only

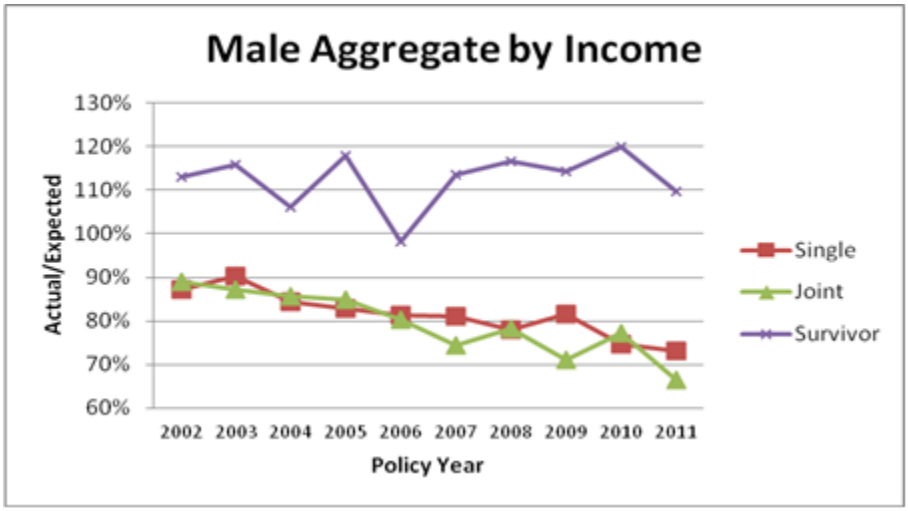
	Exposure		Deaths		Actual/Expected		Standard Deviation	
	Policies	**Income**	**Policies**	**Income**	**Policies**	**Income**	**Policies**	**Income**
Band 0–999	24,528	14,011	1,873	1,011	95.3%	92.9%	2.1%	2.3%
Band 1,000–4,999	32,058	74,406	2,180	4,953	88.8%	87.0%	1.9%	2.1%
Band 5,000–9999	11,613	81,586	710	5,099	76.6%	77.4%	3.1%	3.1%
Band 10,000–19,999	7,695	106,336	463	6,506	72.7%	73.2%	3.7%	3.8%
Band 20,000–49,999	4,890	140,544	193	5,372	48.7%	46.4%	4.7%	4.9%
Band 50,000+	1,780	241,917	62	6,187	49.6%	36.4%	8.4%	14.0%
Total	82,564	658,799	5,482	29,128	84.2%	57.3%	1.2%	4.9%

Single, Female, Non-refund, and Non-registered Experience Only

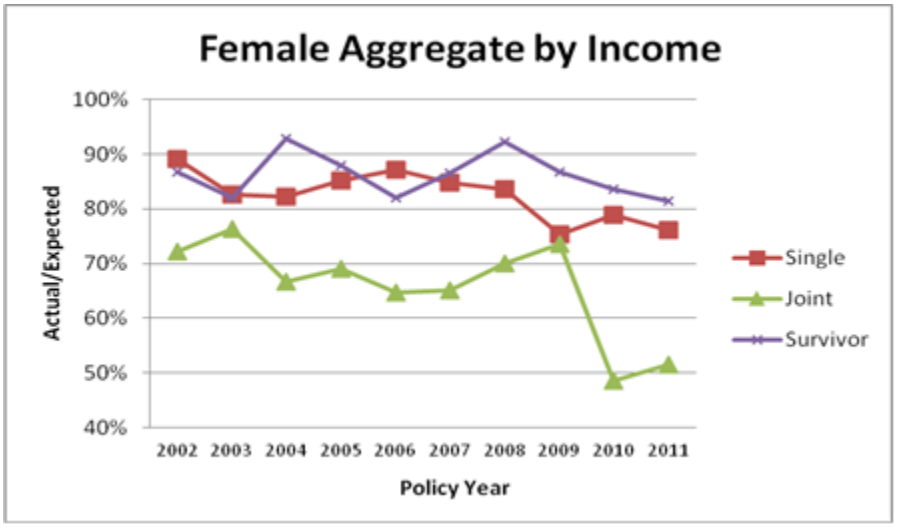
	Exposure		Deaths		Actual/Expected		Standard Deviation	
	Policies	**Income**	**Policies**	**Income**	**Policies**	**Income**	**Policies**	**Income**
Band 0–999	24,643	12,226	2,394	1,127	100.0%	100.7%	1.9%	2.2%
Band 1,000–4,999	42,737	106,284	2,974	7,116	93.9%	92.8%	1.7%	1.8%
Band 5,000–9999	17,116	118,983	1,025	7,056	82.8%	82.1%	2.7%	2.7%
Band 10,000–19,999	11,047	151,477	578	8,020	72.1%	72.2%	3.3%	3.4%
Band 20,000–49,999	5,734	164,461	225	6,217	58.4%	56.1%	4.8%	5.0%
Band 50,000+	1,831	222,603	59	5,398	52.5%	39.5%	8.9%	11.9%
Total	103,108	776,033	7,255	34,935	89.6%	65.6%	1.0%	3.3%

h) Joint and Survivor Policy Observations

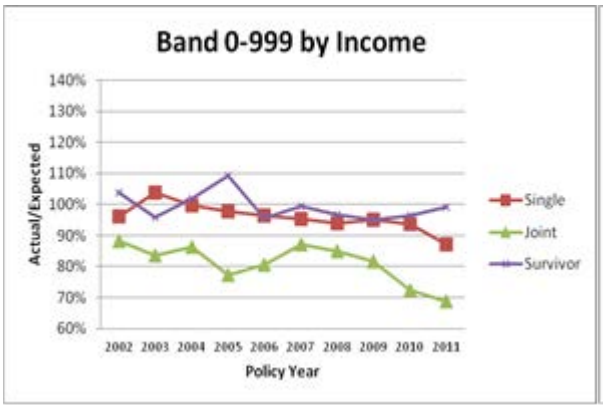
The chart below illustrates the aggregate mortality ratios by income for male lives, single life, joint life (both alive), and joint survivor policies. The data clearly indicate significantly higher ratios for joint survivor policies than joint life policies (both alive) and single life policies. Ratios for joint (both alive) and single policies do not show a significant difference.

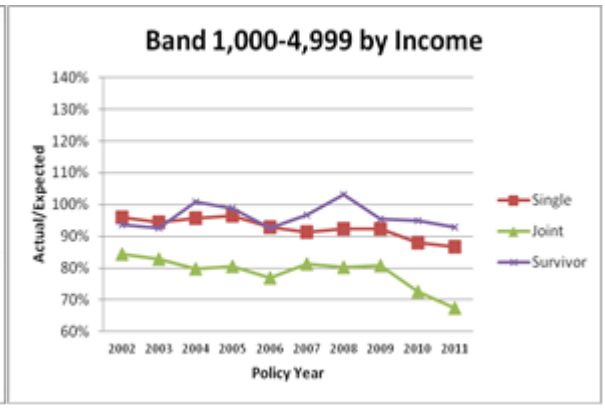


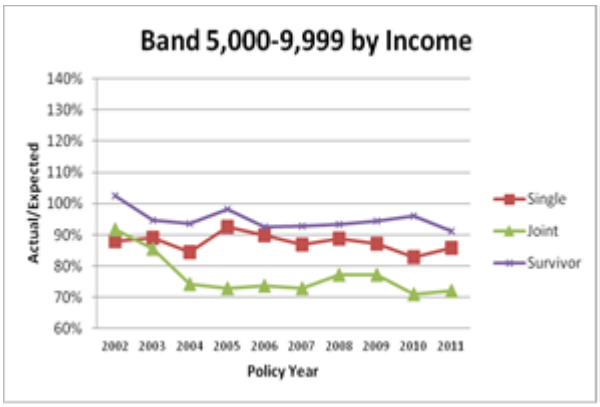
The next chart illustrates the corresponding aggregate mortality ratios for female lives. In this case, the data also indicate higher mortality for joint survivor policies but the difference is less significant. Furthermore, the A/E ratio for female joint life policies (both alive) is significantly lower than female single life and joint survivor policies. The low mortality ratios for joint life policies (both alive) in 2010 and 2011 suggest that recent years are highly sensitive to the IBNR factors used.

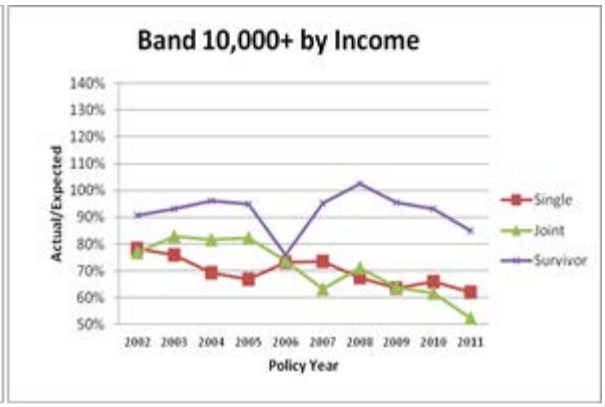


The next four charts illustrate the aggregate mortality ratios for each of the four income bands, for single life, joint life (both alive), and joint survivor policies. Mortality for joint survivor policies appear to be slightly higher than both single life and joint life (both alive) at all income levels. Furthermore, joint life (both alive) policies exhibit a lower mortality experience than single life and joint survivor policies, except single life mortality experience is lower for annualized income greater than $10,000.

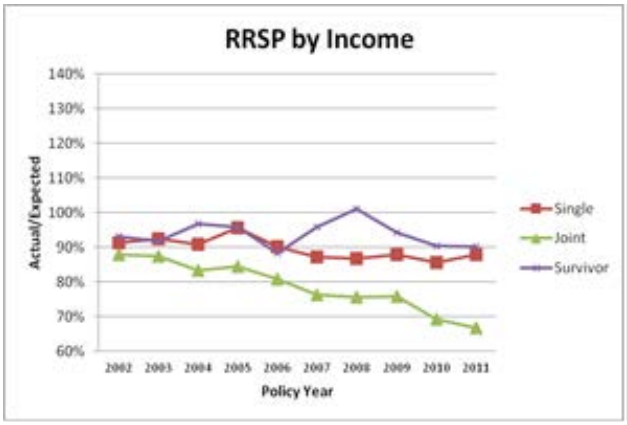


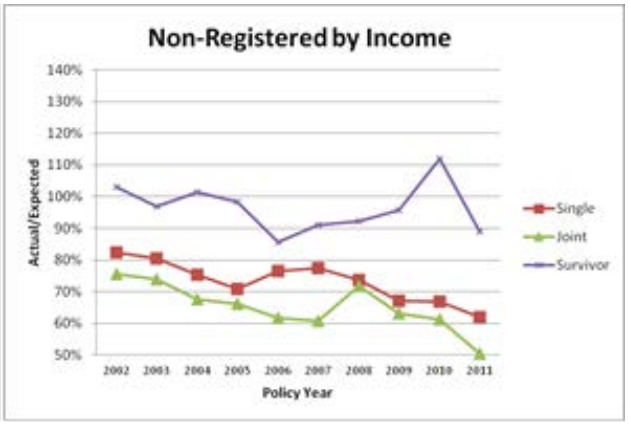






The following two charts illustrate the ratios by tax status. For non-registered policies, mortality is much higher for joint survivors than for joint or single life policies. The difference is smaller for RRSP policies.





5. CONTRIBUTING COMPANIES

The following table of contributing companies shows the proportion of deaths on single life policies submitted for 2002–2011 with IBNR.

Company	2010–2011	2002–2011
Canada Life	18.4%	20.3%
Cooperators	2.3%	1.3%
Great-West Life	7.4%	8.2%
Industrial Alliance	7.1%	7.3%
London Life	0.0%	0.0%
Manulife	26.9%	27.2%
Standard Life	8.9%	7.9%
Sun Life	29.0%	27.9%

6. ADDITIONAL DATA FOR STUDY

This study includes more detailed tables summarizing the data. There are sets of tables for the years of experience 2010 and 2011 and the combined 10 years of experience 2002–2011. A table of contents to each set of tables is given below.

For those who wish to explore the data further, we have included some summaries of the data in binary form in IAMS2011.zip. The zip file also includes a description of the binary files and a sample Excel workbook illustrating the use of the binary files.

7. SUBCOMMITTEE MEMBERS

The members of the Annuitant Experience Subcommittee of the Research Committee are: Diana Pisanu (Chair), Lynn Allen, Catherine Bégin, Mark Harazny, Taylor Wasko, and Jinxia Ma.

Former members Roland Johnson, Johnny Lam, and Julie Chambers also participated in the production of this report.

APPENDIX—STANDARD DEVIATION OF A/E RATIOS IN MORTALITY STUDIES

The following are three standard identities for variance.

$Var(X) = E[X^2] - E[X]^2$

$Var(cX) = c^2 Var(X)$

$Var(X+Y) = Var(X) + Var(Y) + 2\,\mathrm{cov}(X,Y)$

But cov(X,Y) = 0 if X and Y are independent.

Consider a set of policies, having amount K_i and currently at age x_i, for i = 1,2, …, n. Then, since we can assume, for each policy, a binomial distribution with size 1 and probability being that of death in the next year, the following can be derived:

$$E[Deaths] = \sum_{i=1}^{n} q_{x_i}$$

$$E[Claims] = \sum_{i=1}^{n} K_i q_{x_i}$$

$$Var(Claims) = \sum_{i=1}^{n} K_i^{\,2} q_{x_i}(1-q_{x_i})$$

$$Var(A/E) = \left(\sum_{i=1}^{n} K_i^{\,2} q_{x_i}(1-q_{x_i})\right)\left(\sum_{i=1}^{n} K_i q_{x_i}\right)^{-2}$$, given that $E[Claims]$ is a constant

This last formula is the basis for standard deviations for the annuitant mortality study. It is accurate if the expected table is a good representation of the underlying mortality.

This last formula is also the basis for an approximation to the standard deviation for the actual to expected ratio by policies. There are three preliminary statements needed:

1. For policies, K_i = 1.
2. Approximately, 1 – q_x = 1.
3. The observed number of deaths, Θ, is an estimate of $E[Deaths]$

Then approximately, for A/E by policies,

$$Var(A/E) = \Theta\left(E[Deaths]\right)^{-2}$$

$$= \frac{\Theta^2}{\Theta E[Deaths]^2} = \frac{\left(\frac{\Theta}{E[Deaths]}\right)^2}{\Theta} = \frac{(A/E)^2}{\Theta}$$

$$Thus, StdDev(A/E) \approx \frac{(A/E)}{\sqrt{\Theta}}.$$

Note that we could, with greater justification, have used E[Deaths] rather than Θ in the above approximation, but the form above is the one most commonly seen.

The SOA study on large amount experience states on page 31 when referring to the above formula, “It is necessary to use the number of claims in this formula even when the mortality ratio involved is based on an amount of insurance.” (See http://www.soa.org/files/sections/large-amount.pdf.)